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THE INTERRELATION OF SOILS AND PLANT, ANIMAL AND HUMAN NUTRITION[1]

By Dr. E. C. AUCHTER

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OUR knowledge of many aspects of the interrelations between soils, plants, animals and human beings is limited, but some of the work that has been done in recent years gives us fascinating glimpses of the possibility and importance of further discovery. I would go so far as to say that we can now see the outlines of a whole new field of biological, or shall I say, agricultural, research. From what is already known, this phase of agricultural research should lead to a new orientation of agricultural thinking. Certainly it suggests profound implications for human welfare.

The interrelation of the soil, the atmosphere, the plant and the animal is a cycle in which the same materials are used over and over again. Minerals, moisture and certain constituents of the atmosphere under proper conditions of light and temperature enter the plants, and by them compounds of potential energy are made and the excess over their own utilization stored. When such products are eaten by human beings and animals, these compounds are broken down and reworked, energy becomes available for growth and movement, and parts of the compounds are again released into the air in the form of carbon dioxide and moisture or returned to the soil. Such compounds may then be taken up again by plants and rebuilt into new plant bodies. Thus there is an obvious interrelationship, the animals being dependent upon plants, the plants upon soil, and the soil upon parent rock and the materials that are returned to it through the decay of plants and animal products. Thus a great cycle or *wheel of life*

[1] Address of retiring vice-president and chairman of Section O (Agriculture) of the American Association for the Advancement of Science, Richmond, December, 1938.

is established, constructive processes balancing the destructive; the whole, a cycle of energy exchange, which in modifying animal and human development also modifies the whole complex of thought, emotion, happiness, sorrow and the other factors affecting life.

In our scientific procedure so far, we have more or less neglected the interrelationship between soil, plants, animals and man, although in nature this is a fact, a reality. We have been prone to consider the problems of each separately rather than to study them as a whole.

Fairly early in the development of modern science, specialization became necessary, and to-day we have reached the point where the whole of science is rather minutely departmentalized. Each department has its own language and traditions and pursues its own objectives. By this method, we have accumulated a vast amount of information—for example, regarding the classification, chemical and physical properties and management of soils; and regarding the growth and reproduction of plants and animals. Chemistry, physiology, anatomy, pathology, physics, genetics, bacteriology and other sciences have all contributed to the knowledge concerning these subjects but each in its separate department.

That method was necessitated by the vastness and complexity of the facts with which science deals, and it is still necessary. But the unity of nature no less than its complexity is important, and the time has come when we shall have to pay more attention to this unity without neglecting the advantages of specialization.

This is not a new or original idea. It is part of the mental atmosphere of our time, and this association has given a good deal of thought to the possibility of closer coordination between the sciences. But what suggests it strongly to me, with my particular interest in agricultural research, is the direction taken by recent developments in the science of nutrition, both plant and animal, and the parallels or closeness of association of the two.

These developments emphasize the importance to the health of man and animals of certain mineral elements, vitamins, hormones and other factors. At the same time, we are discovering that deficiencies of certain elements essential to the health of the animal organism exist in some soils, while other soils have accumulations of harmful substances. Hitherto the principal objective of many of our plant investigations has been to adjust soil-management practices, change environmental conditions, and in many cases modify the above-ground portions of the plant in order to obtain as large crop yields as possible. But these developments in the science of nutrition suggest that we ought to give more attention to producing crops of the highest *nutritional* quality for man and animals. That would be worth doing even if it should involve a sacrifice in yield, which should not happen, but which, if it did, would run counter to the main trend of our work in the past.

That is what I meant when I said that these interrelationships might affect the orientation of agricultural thinking and practice. Obviously here is a case where an interrelationship must be studied—the interrelationship between the physical well-being of man and the factors in the soil that affect the composition and development of plants. The investigations should include thorough studies of proteins, amino acids, carbohydrates, fats, vitamins, enzymes, hormones, other growth accessory substances, the ordinary minerals and the so-called "trace" or "rare" elements and their effects upon man. Knowledge of the nutritional significance of some of these factors has increased rapidly as a result of research during the past twenty-five years. What we need especially to do now is to put together the various parts we do know so that in acquiring new knowledge we can move forward on a unified front.

Mineral Requirements of Plants and Animals

Plants are dependent on the soil, particularly the nutrients in it, among other things, for their best development and growth. In turn, man and animals are dependent upon plants for their existence. Thus the soil is the mother of all living things. In addition to carbon, hydrogen and oxygen, plants apparently need at least the following chemical elements for normal development: Calcium, phosphorus, potassium, magnesium, sulfur, nitrogen, iron, manganese, boron, copper and zinc. Certain elements, such as boron, are required in relatively small quantities but may be definitely toxic if present in too large amounts.

Animals require all these, with the possible exception of boron, and in addition sodium, chlorine, iodine and cobalt. The possible value of such elements as nickel, bromine, arsenic, lead and fluorine, together with some of the rarer elements, such as molybdenum, strontium, vanadium, uranium, caesium and others sometimes found in the ash of plants, still remains in question. They may be needed to perform certain functions or they may simply be absorbed by plants or eaten by animals with their food, exciting little or no physiological effects. We do know that certain elements such as selenium, thallium, fluorine, arsenic and lead, if present in too large quantities, are definitely toxic to both plants and animals. Our present information indicates that they are undesirable soil constituents even at low concentrations. Undoubtedly, in the future additional elements may be found to be essential for the best development of plants, man and animals.

Elements essential for the normal development of plants apparently occur in sufficient quantities in many soils, yet the normal requirements of the plants

for each of the elements may differ considerably. Thus boron, zinc, copper, iron, manganese, iodine and cobalt are apparently needed only in relatively small amounts. These and others have come to be known as rare, trace or micro elements. Recent investigations in this and other countries have shown deficiencies of these elements in certain soil areas. Certain elements may have been present in only very small amounts during the formation of some soils, amounts insufficient for crop plants; or they may have become exhausted through continuous cropping or partially removed by drainage and erosion through the years. Frequently nutritive elements are present in soils in forms unavailable to plants and special treatment of the soil may be necessary to bring them into the soil solution. The unavailability of iron in calcareous soils, the greater availability of zinc in acid soils, and the "fixation" of phosphorus in many soils serve as examples.

Some Soil Deficiencies Resulting in Nutritional Disorders of Plants and Animals

Results of only a few of the more recent experiments have shown that the following physiological troubles of plants, among others, have been corrected by furnishing the necessary limiting elements: Sand drown of tobacco in the soils of the sandy Coastal Plain by magnesium; chlorosis of tomatoes on some of the calcareous soils in Florida by manganese; internal browning of cauliflower and dry rot of sugar beets in Michigan, crown rot of sugar beets in Ireland, and die-back of citrus in Africa by boron; pecan rosette in the South by zinc; internal cork and drought spot of apples in British Columbia, West Virginia and elsewhere by boron; citrus leaf mottle in California, South Africa and Florida by zinc; little leaf of apples and other deciduous fruits in the West and Northwest by zinc; cracked stem of celery in Florida by boron. Improved yields of potatoes, snapbeans, cabbage, lettuce, peppers, carrots, beets, citrus and corn result when manganese is applied to the calcareous soils of Florida, and white bud of corn on the Norfolk and Hernando fine sands in Florida is prevented with zinc. Improved growth of several crop plants occurs in the organic soils of Florida and the muck soils of Holland and parts of western New York when copper is added. Yellows of tea in Nyasaland, Africa, is corrected and growth of field crops in Oregon and other areas is improved by the addition of sulfur.

Many of the elements just mentioned are likewise important for the best development of man and animals. The necessity of sufficient amounts of calcium and phosphorus and a suitable ratio between them, together with Vitamin D, is recognized. According to Maynard[2] over 70 per cent. of the ash of the animal body consists of calcium and phosphorus, and approximately 99 per cent. of the calcium and 30 per cent. of the phosphorus of the body are present in the bones and teeth. The importance of calcium and phosphorus in bone building and the prevention of osteomalacia and rickets are thus easily understood.

It is not my purpose here to attempt a discussion of the roles of magnesium, sodium, potassium, chlorine, sulfur and zinc in animal nutrition. It is important to point out, however, that some of the rare or trace elements, now considered as essential to plants, likewise play an important part in human and animal nutrition and in the prevention of diseases. Thus iron, as a constituent of the respiratory pigment of haemoglobin, is essential for the functioning of every organ and tissue in the body and plays a fundamental role as a catalyst for cellular oxidation. Its importance, together with copper, in the treatment of nutritional anemia, is well known. Sometime ago in Australia, and more recently in New Zealand, the lack of cobalt in certain soils, and thus in the plants, has been determined as the cause of the so-called "bush sickness" of sheep; and the addition of cobalt is now preventing the trouble. Manganese is concerned in the physiology of reproduction and among other things prevents perosis in chickens. Magnesium is closely associated with calcium and phosphorus, both in its distribution and metabolism, and, among other things, appears to assist in the normal functioning of nerves.

The lack or unavailability of iodine in soils and crops results in human and animal goiter. Iodine-deficient areas exist in the Northwest, the Great Lakes region, and parts of Europe and Asia, such as the Alps, Tyrol, Pyrenees and Himalaya Mountains. Before iodine feeding was practiced in Montana it is estimated that goiter caused an annual loss of many thousands of pigs. According to Maynard, the principal demand for iodine in farm animals occurs during pregnancy.

The Production and Use of Energy

The importance of continuing investigations to determine which elements are essential not only for the best development of plants but for the production of the highest quality plants, which, when consumed, will meet the nutritional requirements of man and animals, is evident. Many factors affect the growth of plants and their value as food.

Nutrient materials must be either in solution or capable of becoming dissolved at the margin of the root hair before they enter the plant body. After their entrance, they become a part of the vast complex of compounds that make up the plant body, and when the plants are consumed by man or animals the nutrients included become part of their bodies. It is the capacity of green plants for manufacturing food—

[2] Leonard A. Maynard, "Animal Nutrition." McGraw-Hill Book Company. 1937.

for accumulating energy as food—that makes them prominent in any system of economy dealing with living things. Green plants, in the presence of sunlight, accomplish this by combining the carbon dioxide of the air and water to form carbohydrates. The minerals and other substances absorbed by the plant from the soil, water or atmosphere are combined with the carbohydrates or other materials formed from them and help to make up such compounds as proteins, fats, vitamins and other growth and regulatory factors.

These combinations of foods, both simple and complex, found in plants, are the chief source of energy and are essential for the health of man and animals. The importance, therefore, of producing plants of the highest nutritional quality can easily be appreciated. In addition, the nutritive value of animal products, as regards mineral content and in a large part vitamins, is dependent on the plant foods they consume. This emphasizes the importance of knowing whether the necessary and desirable nutrients are available in the different soil types of the various regions in the country, to insure not only crop productivity but also that such crops may contain these elements. As previously mentioned, evidence indicates that this is not so in many instances. In other words, certain of the minerals are not present or available in sufficient amounts in some soils for the most satisfactory growth and development of many crop plants. It can be assumed, therefore, that the plants produced in such areas might not furnish certain of the important minerals and compounds needed for the best development and health of man and animals.

This fact takes on considerable significance when we realize that large segments of the population in certain areas of this and other countries obtain practically all their food directly from the plants or from animals that eat the plants produced in their own local communities. Although food products are better distributed to-day than ever before and more variety is available from a much larger area, thus lessening but not eliminating the possibilities of certain deficiencies, there are still great groups of people who are not in a position to purchase much food in addition to that which they produce. Accordingly, in such groups the diet is limited. Even in cities, certain low income groups have a restricted diet. Such dietary deficiencies no doubt result primarily from too low an intake of certain classes of foods, as milk, green vegetables, fish and lean meats. If such foods are also deficient in certain essential elements, the probability of physiological disturbances and reduced vitality is increased. The incidence of anemia has been reported to be especially high among school children in areas where soil deficiencies are known to be responsible for "salt-sick," an anemia-like condition in live stock.

In the past, serious bone, skin, digestive and nervous disorders, among other maladies, occurred in certain localities. It is now known that many of these troubles resulted from restricted diets or from eating plant and animal products produced on soils either deficient in certain elements or containing elements injurious to health. Even to-day there are regions where such troubles as goiter, skin diseases, weak and deformed leg bones, mottled and furrowed teeth and nervous disorders are all too common. A book by J. R. de La H. Marett,[3] entitled "Race, Sex, and Environment," should be read by those interested in this general field.

Another condition, not so striking as those just mentioned but still serious, is the lowered efficiency of certain groups of improperly fed people—people who, although they have no specific disease, have a lowered vitality and, in common parlance, are not up to par. The point I am trying to make is that there are degrees of health, and if conditions of lowered health exist in part because of low quality plant or animal products produced on deficient soils, then the plant, animal and soils investigators have a challenge and responsibility that can not be shirked.

I am well aware that dietary deficiencies among large groups of people can be traced to economic causes—the lack of sufficient income to obtain a good diet easily. But this rather emphasizes than minimizes the responsibility of the agricultural scientist to discover ways of improving limited diets. He may feel rather helpless when it comes to the question of how to increase the purchasing power of large numbers of people, but the other problem, improving the quality of the foods they do get, should be within his grasp.

Factors Affecting the Value of Plants as Food

It is well recognized that the composition of plants grown on different soil types in the same climatic region varies in both organic and inorganic constituents. Analyses of the same kind of plant grown in different regions and showing striking differences in composition are recorded. It is realized that differences in climate existed, and in many cases evidence is lacking relative to the past and present soil-management practices, the species of plant, including the particular variety, its age and the stage of growth at sampling time as affecting composition. But even making such allowances the differences in percentages of some elements are so large as to leave little doubt that they are due to the presence or absence of certain elements in the soil.

It is well known that the chemical composition of plants, with respect to both their mineral and organic content, may be greatly changed by modifying various

[3] J. R. de La H. Marett, "Race, Sex, and Environment," a Study of Mineral Deficiency in Human Evolution. Published by Hutchinson's Scientific and Technical Publications, 32–36 Paternoster Row, London, E. C. 4. 1936.

treatments, such as fertilizer, irrigation or pruning practices. It is thus possible to change the food value of the plants in either the fresh or the cured condition through methods of treatment and handling of the soil and plants. The nutritive value, succulence and crude fiber of crops may thus vary greatly, depending upon the amount and kind of fertilizer applied or the amount and time of applying irrigation water. In general, there is not a direct simple relation but a complex one between water supply and available nutrients. Increasing the amounts of mineral nutrients if water is deficient, or the available water if minerals are deficient, is ineffective in promoting crop yield. An abstract of a recent paper by Thomas, of the Ontario Agricultural College in Canada, entitled, "The Influence of Soil Type and Climate on the Chemical Composition of Fodder Plants," and presented before a symposium of the summer meeting of the American Association for the Advancement of Science at Ottawa in 1938, is significant in this connection. Among other things, he found that there were wide differences in the chemical composition, the crude fiber and ash of plants grown on different soil types, that there was a direct relation between the soil reaction and the percentage of calcium in plants, and that the composition of plants was decidedly influenced by the character of the season. An excellent discussion of this whole problem is presented in the book written by Orr[4] with the assistance of Helen Scherbatoff, entitled, "Minerals in Pastures." Various publications record differences in composition similar to those shown for forage crops in the case of plants used for human consumption.

In addition to considering methods of handling the soil as regards the absorption and utilization of minerals, the synthesis of foodstuffs and energy accumulation by plants, attention must also be given to the way in which the top of the plant is managed as affecting these processes. Too often practices applied to the soil have been antagonistic in their effects to those applied to the part of the plant above the soil. Thus, the time of pruning or cutting plants in relation to their stage and type of growth as affecting later composition and response is important. The differences in palatability and composition of certain vegetables grown by different methods and at various stages of growth are well known. Investigators of the Bureau of Dairy Industry of the United States Department of Agriculture state: "Early-cut hay is more palatable, digestible, and nutritious. Protein content decreases and crude fiber increases with maturity. Proper curing and storage keeps leaves from shattering and retains a good green color—the best indicator of high vitamin A content."

[4] J. B. Orr and Helen Scherbatoff, "Minerals in Pastures." Published by H. K. Lewis and Company, Ltd., 1929.

It is important to recognize that, in addition to water and soil nutrients, attention must also be given to the quantity and quality of light received by the plants during their growth period. Thus by such practices as spraying, pruning and shading the horticulturist can influence the capacity of plants to synthesize, translocate and store carbohydrates. The agronomist accomplishes the same end by cutting, mowing, pasturage and other practices. The interrelation of the various cultural and management practices as affecting the composition and growth of plants has been well described by Kraus and Kraybill[5] and need not be discussed here.

Suggested Investigations and Objectives

Scientists have used water cultures for many years to determine those elements essential for plant growth and will continue to make valuable contributions by this method. Even though some food may be produced by this method in the future, still the great bulk of food needed for human and animal consumption must continue to be produced from the soils of the nation.

The importance, then, of knowing more about the soils of the country, with particular reference to their origin, chemical and physical composition, amenability to various treatments and effectiveness in producing plants of high quality seems clear. Much information on these points is already available, but one of the great needs now appears to be that of making accurate studies and complete analyses of agricultural soil types and areas and the crops that grow upon them under known conditions of climate, fertilization, variety, irrigation and stage of maturity, to determine if deficiencies or excesses of certain elements occur in such soils and plants, and, if so, to correct the conditions with the ultimate view of improving the health of human beings.

The fact that many of the sandy soils of the Coastal Plain, certain calcareous soils and the muck soils, as well as other types, are deficient in some of the minerals essential for plants, animals and man has been pointed out. Similarly, the presence of toxic elements such as selenium and fluorine in certain soil areas has been noted. Doubtless elements not now known to be essential may be found to be so in the future.

There is need for a concerted attempt to correlate composition of foods with soil type, climatic conditions and the practices followed in their production. In addition to those elements whose presence in food is of vital necessity, the fact that certain elements used in combating plant pests may be taken up from the foliage or the soil by the growing plant or may be found in solution in the water supply suggests the urgent need of investigation. A survey should be made of the occurrence of the various elements in fertilizer

[5] E. J. Kraus and H. R. Kraybill, *Oregon Exp. Station Bull.* 149, 1918.

materials, sprays, dusts and the like. Such substances may definitely modify the composition of plants so that the plants either are more nutritious or become toxic to man or animals consuming them. Research should be pushed on the physiological effects of the so-called "rare" or "trace" elements previously mentioned and others not yet studied.

Little is known in detail of the functions of most of these elements. Some of them may have subtle and far-reaching influences. Investigations should be made, therefore, of the nature or availability of the compounds occurring in soils and how they are affected by chemical and biological processes in the soil, of the periodicity of their intake or distribution within the plant, of the differences among species of plants or among strains within a species in their need for mineral elements and their ability to accumulate them and of the effects of chemical additions to the soil upon the composition of the plant.

Thorough plant physiological and anatomical studies should be conducted with reference to the absorption and effects of the various mineral elements, with special reference to the minor elements, including their effect on the elaboration of vitamins, hormones and other compounds. Studies should also be made of the factors influencing availability to the plants of these elements in various soils. The forms in which these various elements occur in plants and the tissues of the plant in which they are stored should be determined. This will involve both field and pot culture studies under carefully controlled conditions, and the further development of special techniques in handling such cultures and of improved analytical methods for the detection of minute quantities of the elements under study.

Consideration should also be given to the digestibility and utilization in the body of the various plant compounds in relation to other factors affecting metabolism and growth.

Studies should be made of the form in which the fertilizing elements are supplied—whether organic, inorganic, colloidal or otherwise and their effects on plant growth and composition. The claim is made that great differences result in the plants used as food, if the fertilizers used are "colloidal."

Consideration should also be given to the influence of such factors as light intensity, length of day, temperature, atmospheric humidity and inherent varietal differences in the plants, in order to learn how to distinguish their effects in relation to various soil factors. Eventually it may be found desirable to conduct breeding investigations for the purpose of developing special strains or varieties of plants in relation to nutritional value.

Effects of degree of maturity, age and kind of plant, rate of growth, harvesting and storage conditions and manufacturing processes on the quantity and availability of the nutritionally essential elements should be investigated.

While the effects of the various minerals, soil conditions, management practices and environmental factors upon plant growth and development are being determined, plants produced in controlled experiments or in various soil areas should be fed to the usual laboratory test animals in order to determine how their rate of development, general health and behavior are affected.

Eventually it should be possible to test the effects of plants of known composition on human beings. In the meantime, studies of the diets of various population groups, especially those dependent upon locally produced food products, with respect to the adequacy of the various mineral elements and growth substances should be enlarged.

The limited status of much of our present knowledge of mineral nutrition with both animals and plants can be explained partially by the extremely small quantities of many elements required to be effective and the lack of sufficiently refined quantitative chemical procedures. The recent development of quantitative spectrographic and polarigraphic methods adapted to the determination of minute amounts of many of these elements is removing an important limiting factor to such studies.

Now the point of this discussion of the interrelationship between soils, plants, animals and human beings can be summed up briefly so far as agricultural research is concerned. The suggestion I would like to convey is this:

There is a mass of material relating to the physiological needs of human beings. It throws new light on what we in agriculture have always known—that the soil and the plant are the primary sources of what might be called the fundamental well-being of people.

Agricultural scientists are taking cognizance of the nutritional studies in their own and related fields. Should we not intensify these efforts and through cooperation of all agencies interested in such studies make greater progress in these fields? Although the problems concerned in such investigations are extremely complex and will require considerable time and funds for their solution, still their great importance in our national life well justifies and in fact demands that such studies be made. Instead of waiting for others to conduct such studies in the future, I think we ourselves should continue to take a leading part in this field. There is need, however, for a closely coordinated scientific attack on the problems. Research on the individual phases should be coordinated and each contribution pointed to the same final objective.

Basically, what is this problem of human nutrition, which is so vital in human well-being? It is a problem of crop production, of food production. That is the most familiar of all problems to agricultural scientists. But hitherto we have thought of it too largely in terms

of quantity—including factors that interfere with quantity production, like plant diseases and insects. It would be no revolutionary step for us to think in terms of *nutritional* quality as well. We have demonstrated that we have the personnel, the training, the facilities and the equipment to make some very significant contributions. We agricultural scientists have felt a strong responsibility for quantity production in the United States. Surely it is just as much our responsibility to further the production of foods of the highest *nutritional* quality—in other words, to dovetail agricultural production with human physiological needs; to move toward the ideal of a better nourished nation.

I shall not attempt here to suggest exactly where such lines of research would lead. But I am sure that one of the most fundamental steps would be a thorough study of our soils from the standpoint of their suitability or unsuitability for the production of certain foods—including the possibility of amending them, if it can and should be done, so that they will give the people who live on them, not just so many pounds of food, but all the complex and subtly balanced nutrients we human beings need. Certainly by this means, general health will be improved and there should be little if any need for adding supplements to the daily diet, except temporarily in certain cases.

It may also mean, among other things, that after thorough surveys and investigations certain soil areas may be found inefficient and undesirable for the production of food, although possibly suitable for the production of crops for certain industrial uses or for forests, parks or recreational centers. It may mean that only certain crops should be grown in certain areas or that it will be necessary to add small quantities of essential but deficient elements in a routine way through fertilizers, irrigation water or sprays to the soil or plants in some areas, so that the people dependent upon the crops in such areas will, automatically and perhaps unknowingly in most cases, have food of high *nutritional* quality. Any foods shipped from such areas would be equally valuable to consumers everywhere.

My thought can be very simply stated. Human well-being is the drive-wheel of agricultural research and this is basic to a prosperous and efficient nation. Here in this realm of nutrition we can get valuable new insights into the true meaning of our work from the standpoint of human well-being. And with new insights will come new objectives.

OBITUARY

JOHN HENRY SCHAFFNER

THE passing of Professor Schaffner from active work in the field of botany means more than the usual sadness experienced in the loss of a friend. He contributed notable papers in a prodigious number and trained a number of prominent botanists who now occupy responsible positions in several of our leading colleges and universities. There are two outstanding traits of character that all who were fortunate enough to know him have commented on—his everlastingly great patience in attempting to solve a problem or to offer explanations to questions and his ability to discover and relate in simple terms many of the problems on which his mind was constantly at work.

In a sense an era has passed with Professor Schaffner. He could be at once a pioneer in the field of cytology, in which his early observations of the reduction division in plants helped establish the firm foundation on which Mendelism now rests, and also to a striking degree a pioneer in the controversy over sex inheritance. He approached this problem in a most unbiased manner, beginning with definitions of primary and secondary sexual states. Even when many geneticists were turning toward a rather rigid Mendelian scheme of sex inheritance, he began gathering the evidence that certain restricted organisms were not safe for the purpose of basing general conclusions on sex inheritance. As a result, his papers threw the whole field open to wider experimentation and to the formulation of broader and more fundamental concepts.

His work in the field of taxonomy also pioneered in the rearrangement according to a phylogenetic system. His system proceeded from morphological studies. It, however, was confirmed in a large measure by serological studies carried out by Metz and his coworkers.

Probably the most patience-trying of his works were those dealing with the problem of sex-reversals and rejuvenation. He succeeded in obtaining four separate rejuvenations in a plant which normally dies after flowering. The spectacular success in this work did not change his habits of work nor cause him to delve as a specialist might into this field to the exclusion of all others.

This leads to the second great trait of his character. All ideas were grist for his mill, to be specifically weighed and tested. It was the simplicity with which he approached each problem that led to his solutions. His observation of minute details often led specialists in certain fields of plant identification to exclaim with surprise at his grasp of a subject. He had a marvelous memory, but his keenness of observation led to his dis-

tinguishing false and true leads with surprising facility. This was equally true in the diagnosis of plant specimens and in observation of plant behavior.

It was not surprising to find him at work on several papers at once. As he once remarked to me "When I get tired or have to wait for one thing, there is always another problem ready for me." This sublime faith in his own endeavor never flagged. It is the mark of a mind at once both great and simple.

John Henry Schaffner was born in Agosta, Marion County, Ohio, on July 8, 1866. He was educated at Baker University, Kansas; the University of Michigan, the University of Chicago and the University of Zurich, Switzerland. In 1897, when he went to Ohio State University as assistant in botany, with the late Dr. Kellerman as professor, there were fewer students in the whole university, 1,200 or less, than there are now in the department of botany each year. Professor Schaffner's work on chromosome behavior between 1894 and 1898 pioneered in the field that has now developed so richly in the application of Mendelism. His papers on the prairies reflect knowledge acquired during his boyhood familiarity with plants now long gone in regions where they were native. His papers on *Equisetum* cover a whole range of plant sciences focused on the single small group of plants he loved so well to study. His eleventh paper in a series on determinate evolution is just off the press two months after his death. With reference to man, in his paper, there is this sentence, "It has been estimated, on a conservative basis, that there are over twelve billions (12,000,000,000) of cells in the human brain alone, and it is evident that the self-conscious personality, my ego, controls this amazing mechanism and other billions of cells of the body to a definite purpose while this sentence is being written." It is a remarkable sentence in that it contains one of the few personal references in his entire writings. Yet even this slight reference to himself turns out, as the context of the paragraph reveals, to be a means of stating a concept of chromosome activity. He seldom thought of himself. His vacations, always with his family, were visits to Kansas, but for the sake of his children and Mrs. Schaffner as well as for the purpose of collecting specimens they often reached Kansas by way of Maine or the Pacific Coast.

Ohio was not neglected in the matter of plant records. The catalogue of Ohio plants is as complete and the herbarium records as numerous as in any state record. Half of these have been added during the last two decades. Perhaps it was the devotion to the herbarium which brought on the heart attack, as it was evident to all of us that the climb of three flights of stairs was a severe strain. When space, more cramped of course than the herbarium, was offered in the basement with the assistants volunteering to do the errand running for changes of specimens to be studied, the answer was only a gentle No, that he preferred to be where all the stored specimens were at hand. The irony of this is that in the original plans for the building in 1914 an elevator to the herbarium was included. For lack of funds at the time this was not installed in the building.

Early in his association at Ohio State University he, with the group that numbers Professors Landacre, Herbert Osborn, Raymond Osburn, James Hine, John Bownocker, and others, founded the Biology Club. This grew into the Ohio Academy of Science. Professor Schaffner was the editor for its entire existence of the *Ohio Naturalist*, the predecessor of the *Ohio Journal of Science*. He was also editor of the *Ohio Journal of Science* from 1916 to 1918, its critical first two years. His services to the academy in this respect are unique. He was its president in 1919.

We have lost a wise counsellor and a devoted friend. We can not think of the man without his works, or the deeds without the personality that produced them. A full bibliography of his 330 papers and books will appear in another place. The Torrey Index lacks about a hundred titles of the full citation of his work. As editor, as teacher, as an example of a tireless investigator, he leaves us a rich gift in his memory.

ADOLPH WALLER

THE OHIO STATE UNIVERSITY

ARTHUR E. HILL

IT is with profound sorrow and realization of great loss that we record the death of Arthur E. Hill, who passed away on March 16, at the age of fifty-eight, at his home, 66 Clinton Place, New York City.

It has been the writer's privilege to have been associated with him over a period of thirty-nine years, during which time he has been a fellow student, a teacher and a colleague.

As a student he was always looked up to and respected by other students for his earnestness with regard to matters worth while, for his rectitude of character and with all this, his happy disposition. He graduated from the College of Arts and Pure Science of New York University in 1901. For the college year 1901–02 he held the Inman fellowship in chemistry at New York University and in 1903 was awarded the degree of doctor of philosophy at Freiburg, Germany.

Upon his return to the United States in 1904 he was appointed instructor in chemistry at his alma mater. In 1912 he succeeded Professor Arthur B. Lamb as head of the department of chemistry at New York University, which position he held until 1937.

As a lecturer and teacher he was known for his great clearness of thought and expression. Frequently, old graduates returning to the campus for a day would

attend one of his lectures to receive anew the inspiration of earlier days. Although Dr. Hill was absorbed in his research the major part of his lecture work was with freshmen, and no one knows how many of these young men were inspired by his wonderful qualities as a teacher.

Aside from his superb ability as an instructor he was an indefatigable worker in his own research laboratory. Many graduate students have worked under his direction. He was not content, however, unless he too was actually carrying on research. His investigations were largely of an inorganic or physical nature, including analytical problems and the solubility relationships in binary, ternary and quaternary systems. His most important publications were with respect to the application of the phase rule to heterogeneous systems.

Although absorbed in his teaching and research he found time to serve as dean of the College of Arts and Pure Science in 1932–33 and in 1935–36.

He became a member of the American Chemical Society in 1901 and served as chairman of the New York Section, councilor of the section, chairman of the physical and inorganic section, associate editor of the *Journal* and was a member of the Chemists Club.

We, his colleagues, his students and his associates in chemistry, will miss the inspiring presence of Dr. Arthur E. Hill. His place can not, we feel, be filled as he would have filled it. We all, however, feel grateful to have known such a man, to have been associated with him and to have been helped by him. He has left us a fine example of rectitude and devotion to duty which will be a vital force for many years to come.

J. P. SIMMONS

NEW YORK UNIVERSITY

SCIENTIFIC EVENTS

THE SWEDISH STATE INSTITUTE OF NATIONAL HEALTH

IN 1936 the Swedish Government instructed certain authorities on different aspects of hygiene to study and report on the possibilities of creating a representative State Institute of National Health.

The British Medical Journal reports that the plan recommended by the authorities consulted has now been published in the form of a 78-page report supplemented by architects' drawings. It is proposed that the three main activities of the new institute shall concern (1) general hygiene, (2) occupational hygiene and (3) dietetics and food control. In each of these three main spheres the institute will conduct investigations and will serve as an adviser both to the authorities and to the general public. It must also give instruction in social welfare and medicine to doctors, nurses and health inspectors, and must also organize health propaganda. A most important activity will be the health aspects of housing. Maternity and child welfare, the care of the tuberculous, medical statistics and medical and social legislation will also be the concern of the institute. It will further deal with the injuries and ailments resulting from faulty conditions of employment. The working conditions of young people and women, working hours and the public health aspects of rationalization in industry will also be dealt with. The control of the manufacture and sale of foodstuffs will be supplemented by certain educational activities with regard to the composition of household dietaries. All these and many other activities are to be conducted in one and the same block of buildings, which will house the administrative staff, the library and the museum. The architect's plans provide for some 170 rooms. It is calculated that the buildings will cost Kr. 1,800,000, and the furnishing about Kr. 400,000. The annual cost of salaries will be Kr. 240,000, and other expenses Kr. 110,000. It is not expected that the buildings will be completed at the earliest before some time in 1940.

STUDY OF THE DISTRIBUTION OF THE FERNS AND FLOWERING PLANTS OF PENNSYLVANIA

WITH a number of institutions cooperating, a comprehensive study of the distribution of the ferns and flowering plants occurring naturally in Pennsylvania is being made in the department of botany of the University of Pennsylvania. The study involves the handling of approximately 300,000 botanical records and has been made possible by the assignment of a special technical and clerical staff from the Works Progress Administration.

Dr. John M. Fogg, Jr., assistant professor and curator of the herbarium, is directing this study. Other members of the faculty and a group of graduate students in botany are assisting in scientific aspects of the project. In addition to the University of Pennsylvania, other institutions in the state, including Pennsylvania State College, the Carnegie Museum and the University of Pittsburgh, the State Herbarium at Harrisburg and the Academy of Natural Sciences in Philadelphia are cooperating by making available all pertinent records and information.

According to Dr. Fogg, a separate card upon which is printed the entire list of sixty-seven Pennsylvania counties is being used to record detailed information concerning each one of the 3,000 or more species of ferns and flowering plants which must be covered in the survey.

Thus, if specimens of a certain plant have been collected in Wayne, Lehigh and Westmoreland Counties, that information is entered on the card under those counties. In each instance, there is recorded the exact locality where the specimen was found; the collector's name, date of collection and the institution having the specimen on deposit. Accompanying each card, which measures ten by fourteen inches, there is a second card bearing an outline map of the state with county divisions and outstanding physical features. On these maps small dots are placed to designate localities at which the specimens of a particular species have been found. The completed map therefore enables students to visualize at a glance the exact known distribution of a given species within the state and to determine the physical factors controlling its occurrence.

Only one set of maps and cards is being prepared for each species, but they are so designed as to lend themselves readily to reproduction on micro-film. Thus it will be possible to furnish to interested institutions and individuals a copy of all records made. Eventually, the entire results of the study will be published in a volume which will include not only the information on the cards and maps, but also data concerning soil conditions, climatic factors and other dynamic influences affecting distribution of the native plants.

The 300,000 specimens upon which records and information essential to the study are based are distributed approximately as follows: The Carnegie Museum and the University of Pittsburgh, 100,000; the Academy of Natural Sciences in Philadelphia, 100,000; the University of Pennsylvania, 50,000, and the State Herbarium and Pennsylvania State College, 25,000 each.

HONORARY MEMBERS OF THE HORTICULTURAL SOCIETY OF NEW YORK

THE Horticultural Society of New York, in tribute to outstanding horticulturists of the United States, has elected the following to honorary membership:

Professor Liberty Hyde Bailey, professor of horticulture at Cornell University from 1888 to 1903; dean and director of the New York State College of Agriculture from 1903 to 1913 and now emeritus professor of agriculture at Cornell.

Dr. David Fairchild, member of staff of the Bureau of Plant Industry, United States Department of Agriculture, from 1889 until his recent retirement as senior agricultural explorer.

Dr. U. P. Hedrick, until his recent retirement director for many years of the New York State Agricultural Experiment Station at Geneva. He was the recipient of the White Medal for horticultural work in 1926 and the Wilder Medal in 1930.

William Hertrich, superintendent of the Huntington Garden, San Marino, Calif.

Dr. J. Horace McFarland, leader in conservation and development of parks; president emeritus of the American Rose Society; lecturer, author, developer of Breeze Hill Gardens for testing roses and other ornamental plants and recipient of George Robert White Medal of honor for horticulture.

B. Y. Morrison, principal horticulturist in charge of the division of plant exploration and introduction of the United States Bureau of Plant Industry since 1934; acting director of the National Arboretum in 1937 and since 1938 editor of the *National Horticultural Magazine*.

Professor A. P. Saunders, professor of chemistry at Hamilton College, Clinton, N. Y., since 1900, and dean of the faculty from 1909 to 1926; noted for his work in plant breeding and the promotion of horticulture.

John C. Wister, secretary of the Pennsylvania Horticultural Society for many years and director of the Arthur Hoyt Scott Foundation for Horticulture.

THE DUNDEE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE British Association for the Advancement of Science will meet at Dundee, Scotland, from August 30 to September 5. The inaugural general meeting will take place in Caird Hall, City Square, at 8:30 P.M. on Wednesday evening, August 30, when Sir Albert Seward will deliver the presidential address on "The Western Isles through the Mists of Ages."

The preliminary program states that having in view the aims, which are among those prescribed for the association in the first statute adopted on its foundation, namely, "to obtain more general attention for the objects of science, and the removal of any disadvantages of a public kind which impede its progress," the council, in cooperation with the sections and the Division for the Social and International Relations of Science, have considered the growing strength of the public demand for a more systematic presentation of selected subjects of scientific investigation in their bearing on the life of the community. It calls special attention to this division, which was established at the Cambridge meeting in 1938 and which will hold sessions during the Dundee meeting. The following provisional program is being arranged:

Thursday, August 31. Afternoon session for papers and discussion on the coordination of scientific research on population and other topics.

Sunday, September 3. Evening meeting, open to members and the public, at which Sir Richard Gregory, Bart., chairman of the division, will deliver an address on "Science and Social Ethics."

Wednesday, September 6. Morning session devoted to discussion on nutrition.

The division is empowered to hold sessions at times

and places other than those of the annual meetings of the association and arrangements are in hand for:

A meeting in London in May for papers and discussion on certain aspects of the work of the division, including a review of its first year's work, and a meeting in Manchester during the early summer, in collaboration with the Manchester Literary and Philosophical Society, at which the Alexander Pedler Memorial Lecture will be delivered by Professor H. Levy on methods of studying the social problems of science.

Two evening lectures will be given, taking the place of the customary evening discourses:

Sunday, September 3. The address by Sir Richard Gregory, Bart., on "Science and Social Ethics," announced above.

Tuesday, September 5. Address by Dr. Isaiah Bowman, president of the Johns Hopkins University, under the arrangement concluded last year with the American Association for the Advancement of Science, by which, in alternate years, a speaker from America will be invited by the British Association, and one from Britain by the American Association.

Public lectures will be given in Dundee and neighboring towns during the period of the meeting.

Two previous meetings of the British Association have been held in Dundee, in 1867 under the presidency of the Duke of Buccleuch, and in 1912 under that of Sir Edward Sharpey Schafer. The meeting in 1912 was the occasion of a splendid act of generosity by a citizen of Dundee, the late Sir James Caird, whose gift of £11,000 to the funds of the association enabled it to commemorate his name in the Caird Fund, which is devoted to scientific research.

THE FIFTIETH ANNIVERSARY OF THE JOHNS HOPKINS HOSPITAL

THE fiftieth anniversary of the founding of the Johns Hopkins Hospital was celebrated on May 4, 5 and 6. The first exercises opened in Hurd Memorial Hall, when Dr. Winford H. Smith, superintendent of the hospital, made the welcoming address. The various programs for the reading of papers were presided over on May 4 by Dr. Edwards A. Park, Dr. Warfield T. Longcope and Dr. Nicholson J. Eastman; on May 5 by Dr. Warfield M. Firor, Dr. Thomas S. Cullen and Dr. William G. MacCallum, and on May 6 by Dr. A. C. Woods, Dr. Adolf Meyer and Dr. Eastman.

A public meeting was held in the afternoon of May 4, at which an address of welcome was made by Henry D. Harlan, president of the university's board of trustees. There were greetings to the hospital from Dr. Irvin Abell, president of the American Medical Association, conveyed by Dr. Thomas S. Cullen; greetings from Major Julia C. Stimson, U. S. A. (retired), president of the American Nurses' Association; from Dr. Fred Carter, president-elect of the American Hospital Association; from Dr. Howard Naffziger, president of the American College of Surgeons, and Dr. O. H. Perry Pepper, president of the American College of Physicians.

Dr. James B. Herrick, professor emeritus of medicine, Rush Medical College, delivered the principal address. He offered congratulations on the "glorious fifty years of service" of the Hopkins.

Later presentations to the hospital were made in the same hall, with Mr. Harlan presiding. Dr. Cullen presented a plaque in memory of Dr. Frank R. Smith; Dr. Warfield T. Longcope presented a portrait of Dr. Thomas B. Futcher, and Dr. Arthur Shipley presented a portrait of Dr. Thomas R. Boggs.

The program included the nurses' commencement exercises with an address by Miss Elsie M. Lawler, superintendent of nurses and principal of the Hopkins School of Nursing, whose address was entitled "Fifty Years in Retrospect." There were also demonstrations of the newer developments in the teaching of student nurses; a luncheon, a moving picture of Dr. Welch and of the work of the Johns Hopkins Hospital.

The anniversary banquet was held at the Emerson Hotel on the evening of May 5, with Dr. J. M. T. Finney as toastmaster. The speakers included Dr. Howard A. Kelly, Dr. Henri La Fleur, Dr. Lewellys F. Barker, Dr. William G. MacCallum and Miss Lawler.

A historical play in four scenes by Dr. Alan M. Chesney, entitled "The Flowering of an Idea," presented some of the early events in connection with the Johns Hopkins Hospital, which had an important bearing upon its subsequent development.

SCIENTIFIC NOTES AND NEWS

THE Faraday Medal of the British Institution of Electrical Engineers was presented on May 4 to Dr. William D. Coolidge, director of the Research Laboratories of the General Electric Company at Schenectady. The ceremony took place at the northeastern convention of the American Institute of Engineering at Springfield, Mass. The presentation was made by Dr. Gano Dunn, honorary secretary of the British organization in the United States.

THE George M. Kober Medal "for outstanding service in medicine" was presented at the annual meeting of the Association of American Physicians at Atlantic City to Dr. George Hoyt Whipple, dean and professor of pathology at the School of Medicine

and Dentistry of the University of Rochester. Dr. Louis Hamman, of Baltimore, vice-president of the association, made the presentation.

THE Mendel Medal of Villanova College "for outstanding achievement in science" was presented on May 4 to the Rev. Dr. John M. Cooper, professor of anthropology at the Catholic University of America, Washington, D. C., in recognition of "his work on the American Indians, their social system and religion."

THE annual Howard Taylor Ricketts Prize of the University of Chicago has been awarded to George Hartley, Jr., an assistant in the Zoller Memorial Dental Clinic and a student of Dr. Paul R. Cannon in the department of pathology. The Ricketts prize was established in 1913 in honor of Dr. Howard Taylor Ricketts, who discovered the typhus germ and died a martyr to his discovery in Mexico. Awarded annually on May 3, the anniversary of his death in 1910, the prize is given to a student in the departments of pathology or bacteriology for notable research.

A DINNER attended by two hundred and twenty-five colleagues and friends was given on April 29 in New York City at the Waldorf Astoria Hotel in honor of the sixtieth birthday of Dr. Alfred E. Cohn, of the Rockefeller Institute for Medical Research. At the dinner he was presented with a volume consisting of more than three hundred congratulatory letters.

DR. ADOLF LORENZ, emeritus professor of orthopedic surgery at Vienna, celebrated his eighty-fifth birthday on April 21.

DR. PHILIPP FURTWÄNGLER, professor of mathematics and geodesy at the University of Vienna, celebrated his seventieth birthday on April 21.

DR. G. B. WEBB, of Colorado Springs, was elected president of the Association of American Physicians at the meeting at Atlantic City on May 3. Dr. Louis Hamman was elected vice-president; Dr. A. H. Gordon, of Montreal, councilor, and Dr. O. H. P. Pepper, of Philadelphia, delegate to the Congress of American Physicians and Surgeons.

AT the annual meeting in Toronto of the American Society for Experimental Pathology the following officers were elected: *President,* Ernest W. Goodpasture, Nashville; *Vice-president,* Shields Warren, Boston; *Secretary-treasurer,* Paul R. Cannon, Chicago; *Incoming Member of Council,* Balduin Lucké, Philadelphia.

PROFESSOR LOUIS P. HAMMETT, of Columbia University, was elected chairman of the New York Section of the American Chemical Society at the recent annual meeting. Dr. Robert Calvert, consulting chemist and chemical patent attorney, was named to the newly established post of chairman-elect, and William W. Winship, the present chairman of the section, becomes treasurer. Dr. Cornelia T. Snell was reelected secretary. Directors chosen in addition to the officers are Professor Ralph H. Müller, of New York University; Father Francis W. Power, of Fordham University, and Dr. Robert R. Williams, of the Bell Telephone Company.

AT the Massachusetts Institute of Technology, the title of emeritus professor has been conferred on Dean William Emerson, of the School of Architecture, and on Professor W. Spencer Hutchinson, head of the department of mining engineering. Professor Charles E. Locke has been appointed acting head of the department of mining engineering. He will succeed Professor Hutchinson upon his retirement in June.

DR. GEORGE D. BIRKHOFF, of Harvard University, has been appointed to a Walker-Ames professorship of mathematics at the University of Washington for the summer quarter.

PROFESSOR CHARLES M. DODD, of the Missouri School of Mines, has been appointed head of the department of ceramic engineering at the Iowa State College. He will succeed Professor Paul E. Cox, who will continue as professor of ceramic engineering; Dr. William G. Cochran, mathematician in the statistical department of Rothamsted Experimental Station, has been appointed professor of mathematical statistics.

DR. GUSTAV A. HEDLUND, associate professor of mathematics at Bryn Mawr College, has been appointed professor of mathematics at the University of Virginia.

DR. ROGER B. FRIEND has been appointed Connecticut state entomologist and head of the department of entomology of the Agricultural Experiment Station at New Haven. He succeeds the late Dr. W. E. Britton, who was state entomologist from 1901, when the office was established, until his death last February.

DR. CHARLES W. REES, of the zoological division of the U. S. Bureau of Animal Industry, has been appointed senior protozoologist in the National Institute of Health.

W. D. APPEL, chief of the textile section of the National Bureau of Standards, has been appointed acting chairman of the research council of the U. S. Institute for Textile Research, and Edward R. Schwarz, professor of textile engineering of the Massachusetts Institute of Technology, has been made vice-chairman. They succeed, respectively, W. E. Emley, chief of the Organic and Fibrous Materials Division of the National Bureau of Standards, and

Dr. H. DeW. Smith, treasurer of the A. M. Tenney Associates.

DR. J. M. STAGG has been appointed superintendent of Kew Observatory, England, in succession to Dr. F. J. W. Whipple, who retired on March 31.

DR. E. W. R. STEACIE, associate professor of chemistry at McGill University, has been appointed director of the Division of Chemistry of the National Research Council of Canada, in succession to Dr. G. S. Whitby, who recently resigned to accept the post of director of Chemical Laboratories of the Department of Scientific and Industrial Research in Great Britain. It is expected that Dr. Steacie will assume his new work early in July.

DR. ALEXANDER LURIA, head of the department of psychology of the Medico-Genetic Institute of Moscow, has been elected Salmon Memorial Lecturer of the New York Academy of Medicine for 1940. On April 12, 19 and 26 he spoke on "The Psychological Approach to Brain Pathology." He will give a fourth lecture at a city to be selected later.

DR. ALBERT SZENT-GYÖRGYI, professor of medical chemistry at the University of Szeged, Hungary, will deliver the eighth Harvey Society lecture of the current series at the New York Academy of Medicine on May 18. He will speak on "Biological Oxidation and Vitamins." On May 26 he will speak before the Institute of Medicine of Chicago, where his lecture will be entitled "The Mechanism of Biological Oxidation."

DR. CHARLES F. POE, professor of chemistry at the University of Colorado, gave the principal address at the recent installation of the Utah Alpha Chapter of Alpha Epsilon Delta, national honorary premedical fraternity, at the Utah State Agricultural College and at the installation of the Wyoming Alpha Chapter at the University of Wyoming.

DR. DOUGLAS JOHNSON, professor of physiography at Columbia University, addressed the faculty and students of Vassar College on April 14 on the "Geologic Basis of Landscapes—a Study in the Conservation and Utilization of Scenery." On March 30 he gave the convocation address at the University of West Virginia, on the occasion of the installation of a new chapter of Sigma Xi, where he discussed "The Mysterious Craters of the Carolina Coast."

DR. NEVIN M. FENNEMAN, professor of geology at the University of Cincinnati, gave a series of lectures to the faculty and students of the department of geology at the University of Kansas during the week of April 17. The lectures were arranged on an exchange basis with the department of geology at the University of Cincinnati. Dr. Kenneth K. Landes will give a similar series of lectures in Cincinnati next autumn.

DR. K. LINDERSTRØM-LANG, director of the chemical division of the Carlsberg Laboratory, Copenhagen, on March 27 addressed a joint meeting of the Duke University Hospital Medical Society and the Duke University Chapter of Sigma Xi on "Recent Histochemical Studies on Enzymes." On April 17, Dr. E. Fullerton Cook, chairman of the U. S. Pharmacopeia Revision Committee, lectured on "The Physician and the Pharmacopeia."

DR. J. A. BECKER, of the technical staff of the Bell Telephone Laboratories, has completed a tour of the Midwest, at which time he presented a lecture on "Electron Microscopes and Some of Their Uses" to groups at the Chicago Physics Club, the State University of Iowa, the Iowa State College, the University of Kansas, the Kansas State College, the University of Missouri, Washington University and the Ohio State University. Dr. Becker demonstrated one type of microscope having a magnification of 500,000.

THE Rutherford Memorial Lecture of the Royal Institution, London, was given early in April by Sir Henry Tizard. The lecture was entitled "Lord Rutherford, His Life and Influence on Chemistry."

THE six hundredth anniversary celebration of the University of Grenoble will be held from May 13 to 15.

THE international committee has voted to hold the next meeting of the International Congress of Psychology at Edinburgh in the summer of 1940.

THE annual meeting of the Field Conference of Pennsylvania Geologists will be held at Morgantown, W. Va., at the invitation of the West Virginia Geological Survey, from May 27 to 30. Those interested are requested to address Dr. Paul H. Price, state geologist, Morgantown, or M. N. Shaffner, secretary-treasurer, care of Pennsylvania Topographic and Geologic Survey, Harrisburg.

THE Association of Southeastern Biologists held its third annual meeting at Duke University on April 14 and 15. Thirty-three papers in the fields of zoology and botany were presented. The guest lecture was given by Dr. Harden Taylor, president of Atlantic Coast Fisheries Company, who spoke on "Biology and the Great Fisheries." There were a hundred biologists from seven southeastern states in attendance. The following officers were elected: *President,* Dr. H. L. Blomquist, Duke University; *Vice-president,* Dr. J. Speed Rogers, University of Florida; *Secretary-treasurer,* Dr. Donald C. Boughton, University of Georgia, and *Members of the executive committee,* Dr. R. O. Christenson, Alabama Polytechnic Institute, and Dr. E. E. Reinke, Vanderbilt University.

THE New York State Association of Applied Psychologists met at Cornell University on April 29, with

seventy members in attendance. Symposia were devoted to "The Training of Psychological Counselors" and "The Work of the School Psychologist." Addresses were given by Dr. F. H. Allport on "Methods of Personality Study"; by Dr. Ethel Waring on "Generalizing Abilities of Preschool Children"; and by Dr. W. V. Bingham, president of the association, on "Vocational Guidance in New York State." Fordham University was selected as the place of the next annual meeting.

THE Royal Society, London, is preparing for the Ministry of Labor a register of scientific research workers whose services could be used for the nation in the event of war. Professor Archibald V. Hill, Foulerton research professor and joint honorary secretary, is chairman of a subcommittee for scientific research attached to the Central Register Advisory Council of the Ministry of Labor. Sir Walter Moberley, chairman of the Advisory Council, is reported to have stated that "The general scheme includes the registration of technicians, engineers, architects, and others. This work is being dealt with by their appropriate professional institutions. So far as the scientists are concerned, we felt that the Royal Society was the natural body to undertake the work and that Professor Hill, as one of its secretaries, was the right man to act as chairman."

THE spring meeting of the Indiana Academy of Science was held on May 12 and 13 at New Harmony, which was an early center of science in the West, being the home at one time of William Maclure, Charles Alexander LeSueur, Thomas Say, David Dale Owen, Robert Dale Owen and Richard Owen, and being visited once by Sir Charles Lyell. The program was devoted in part to lectures on the early scientific history of New Harmony as well as to the more recent studies in the geology, flora and fauna of the area. There were also conducted tours among the sites of historic and scientific interest.

THE twenty-eighth annual report of the Brooklyn Botanic Garden for the year 1938 records a total attendance for the year of more than 1,628,000, with a record week-end attendance from noon, April 30, to 5 P.M., Sunday, May 1, of 56,145, or at the rate of about 155 every two minutes. Two new gates were constructed during the year, financed by a bequest of $10,000, and a beautiful memorial approach, consisting of stone seats, water basins, fountain and monumental columns, just inside the main entrance, was made possible by a gift of $32,000. Private funds contributed, in addition to income from endowment, were in excess of $54,000. About 56 per cent. of the total maintenance budget was met from private funds, and about 43 per cent. from the tax budget of New York City. A new garden of medicinal and culinary herbs was opened to the public in September. About twenty pages of the report are devoted to summaries of the research work in progress during the year.

DISCUSSION

WILL IODINE COME TO BE CONSIDERED AN ESSENTIAL PLANT NUTRIENT?

INFLUENCE of iodine has been studied in water and soil cultures at Oregon Agricultural Experiment Station beginning in 1929. Crop indicators used in experiments include alfalfa, clover, peas, corn, lettuce, tomatoes and sunflowers.

Mathematically significant increases in yield have been obtained, especially with alfalfa, clover and lettuce, while germination has been stimulated with corn. Iodine seems to promote development of chlorophyll or green pigment in plants. Soil micro-organisms appear to be affected, particularly nitrogen-fixing legume root bacteria. Yeasts are known to be stimulated by iodine.

Favorable concentration in flowing culture solutions is found to be one fourth to one half part per million. Flowing solutions were connected in series by Waldo Carlson, graduate assistant, who found the age of solutions affected stimulation and older solutions were more beneficial. The iodine may change to organic form before it is effective. With alfalfa in "sterile" culture this concentration was inhibitive, an indirect effect is indicated. James C. Lewis, graduate assistant, found stimulation from iodine in soil cultures using a soil well supplied as to total iodine. Two to four pounds of iodine as potassium iodide were found to be significantly stimulating in soil cultures with Aiken and Deschutes soil series. Other soils have given negative results. Even where increase in yield was small the iodine content of the plants has been increased many-fold according to analyses by Mr. Lewis.

Comparison of methods for iodine determination has been made in the laboratory of Dr. J. R. Haag, nutrition chemist. Some improvement has been made in adapting the Harvey procedure for analysis of soils and plant materials.

Oregon soils, waters and plants are frequently low in iodine, yet certain deep wells, lakes and soils are found to be well supplied. Iodine in Oregon soils may run from ½ part to 15 parts per million. The iodine content of Oregon waters is from .01 to 20 parts per

million. The relation seems sharpest between iodine content of water and goiter. Soil iodine seems to accumulate some with organic matter and to be higher in soils of sea-bed origin. Baumann in 1895 found absence of iodine in plants affects thyroid. Aso in 1903 recommended seaweed as fertilizer, due to its iodine content.

According to a map of the United States prepared by Dr. J. F. McClendon there is a high incidence of goiter in certain areas, including much of the Pacific Northwest. Head lettuce and spinach are among the plants that contain relatively more iodine. Marine by-product fertilizers afford a source of iodine. Small-scale field trials are being made this season. If successful, potassium iodide might be added in irrigation water or large seed may absorb sufficient amounts for plant needs.

W. L. POWERS
OREGON STATE AGRICULTURAL COLLEGE

RANGE PLANT NEWLY FOUND TO BE POISONOUS

WHILE searching for the cause of death of cattle in a small herd in northeastern Colorado, several native plants suspected of causing poisoning were fed. One of these plants, *Picradeniopsis oppositifolia* (Nutt.) Rydb. or *Bahia oppositifolia* A. Gray, was found to have poisonous properties, though hitherto unsuspected. The plant is a low-growing, gray-green perennial three to six inches tall with opposite, three to five divided leaves. It belongs to the thistle family and has small tight heads of yellow flowers.

Feeding experiments were conducted to determine its actual toxicity for cattle and sheep. Approximately six quarts of the finely ground plant was force-fed to a 650-pound steer by means of a stomach tube. Typical symptoms of HCN poisoning were produced, starting in about 30 minutes. Although the animal showed the accelerated respiration, trembling and muscular incoordination which are characteristic in HCN poisoning, these symptoms lasted for only about 30 minutes. Following this, although the animal had apparently recovered from the effects of the HCN, a marked depression was observed, which endured for more than three hours, but the eventual recovery was complete. Identical results were obtained when fed to guinea pigs.

A mature ewe was also force-fed, using 1½ quarts of the chopped-up plant. The chain of symptoms was very similar to those produced in the steer, but more severe. Again a period of depression was followed by complete recovery.

Bahia oppositifolia is not readily eaten by stock except when forage is scarce, and it is questionable if they ever eat enough to prove injurious.

However, since quantitative chemical analyses of the plant indicate an average HCN content of .03 per cent. it may be considered potentially dangerous to live stock.

A. W. DEEM
FRANK THORP, JR.
L. W. DURRELL
COLORADO AGRICULTURAL EXPERIMENT STATION

THE TRANSPORT OF WATER TO ANODE OR CATHODE THROUGH NON-AQUEOUS LIQUIDS

EXPERIMENTS have been reported recently by W. J. V. Osterhout and J. W. Murray in the May 13, 1938, issue of SCIENCE, page 430, and by H. E. Bent in the December 2, 1938, issue of SCIENCE, page 525, concerning the "Movement of Water from Concentrated to Dilute Solutions through Liquid Membranes."

The author has conducted experiments with non-aqueous liquid membranes, separating two equal portions of the same salt solution in water and has found that in some cases water is transported to the cathode solution, while in other cases water is transported to the anode solution, when platinum electrodes are dipped in the two salt solutions and connected to a source of direct current of 110 volts or more. With 110 volts the transport of water through an intervening membrane of benzaldehyde or of carbon tetrachloride is very slow, requiring several days or weeks before showing an appreciable change in the two volumes of aqueous solution. At voltages around 450 to 500 the transport of water is much more rapid, and a considerable difference in the two volumes may be observed within two days.

The apparatus in each experiment consisted of a U-tube with benzaldehyde or carbon tetrachloride filling the curved part of the tube with an equal volume of the saturated aqueous solution of the salt introduced into each arm of the tube above the liquid membrane simultaneously and carefully so that the solution would lie on top of the liquid membrane, with platinum wire electrodes dipping into the aqueous solutions and connecting to the direct current source, at first a 110 volt d.c. supply line, later a transformer-vacuum tube rectifier, which would furnish up to 500 volts and was designed to produce continuously up to 100 milliamperes. Much lower currents than this passed through the solutions separated by the liquid membranes.

When the electrolyte was ammonium oxalate, water was transported to the cathode side through benzaldehyde or through carbon tetrachloride. Likewise, when the electrolyte was sodium oxalate, water was transported to the cathode through benzaldehyde or through carbon tetrachloride. When the electrolyte was cupric nitrate, water was transported to the anode side through benzaldehyde and through carbon tetrachloride. These phenomena I have interpreted as indi-

cating that the ammonium ions and sodium ions are hydrated to a greater extent than the oxalate ions and that the nitrate ions are hydrated to a greater extent than the cupric ions; that the transport of water is due to this greater hydration of the ammonium and sodium cations of the oxalates, thus causing transport of water to the cathode side, and to the greater hydration of the nitrate anion, thus causing transport of water to the anode side in the cupric nitrate experiments.

There are two possible paths by which the water may be transported. The hydrated ions may actually move through the body of the intervening liquid membrane or they may pass along the outer edge of the liquid between the liquid and the glass wall. The liquid membrane takes on a cloudy appearance both with the benzaldehyde and the carbon tetrachloride; but this might occur in either type of movement of the hydrated ions. In any event, by whatever path the ions are transported, there results an increase of acid in the anode side and an increase of base in the cathode side, indicating that the transport of water is accompanied by the transport of the cations to the cathode side and anions to the anode side of the liquid membrane, that it is not a simple case of electroendosmosis of the water but rather the movement of hydrated ions. Another point that would seem to rule out the idea of electroendosmosis is that in the experiments with ammonium oxalate in water over benzaldehyde, deposits of benzaldehyde were detected on the cathode, even though it had never been in direct contact with the benzaldehyde. No such deposit of benzaldehyde was found on the anode. This seems to indicate that the benzaldehyde bears a positive charge and tends to move toward the cathode. In electroendosmosis the water moves in a direction opposite to the direction in which a colloidal membrane tends to move. Therefore, water would be expected to move toward the anode if it moved essentially by electroendosmosis; whereas, water was actually transported to the cathode side in this experiment.

Preliminary quantitative determinations of the amounts of ammonium ion, oxalate ion and water transported indicate that in electrolyzing ammonium oxalate through benzaldehyde two oxalate ions migrate, while one ammonium ion migrates. This would seem to indicate a rather high degree of hydration of the ammonium ion producing a large, heavy, slow-moving ion. Though it appears rather high, preliminary determinations of the number of water molecules transported for each ammonium ion transported give a value of 892.

Other experiments of a similar nature are being conducted by the author in the hope that it may become possible to measure directly the degrees of hydration of the various ions, a subject of great importance to all who work with aqueous solutions.

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PROPOSING THE TERM, PREDATEE

FOR those working in ecology or fields of animal control there has developed a need for a term to designate animals preyed-upon, corresponding to "predator" for those which do the preying. The word "predatee" would be the logical one, and we propose it for the purpose.

The word predator has only comparatively recently been included in the dictionaries. It of course appeared as an answer to the need for a noun growing out of the word predatory. Now, as an outgrowth of ecological studies requiring an expression of both sides of this food relationship among animals, there comes the need for the other word, namely, predatee. Like the terms, employer and employee, the two terms are necessary to each other. One can not very well exist without the other. They express complementary parts of a single concept. Hence this proposal for recognition of the word.

L. D. WOOSTER
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SOCIETIES AND MEETINGS

THE AMERICAN PHILOSOPHICAL SOCIETY

THE annual general meeting of the American Philosophical Society was held on April 20, 21 and 22 in its Hall on Independence Square, where its meetings have been held for almost one hundred and fifty years, for it was on November 13, 1789, that the society first met in the then newly finished building which has ever since been its home. The meeting this year was attended by about 200 members and invited guests, while approximately twice that number were present at the Penrose Memorial Lecture on Friday evening, which was given by Dr. Eduard Benes, formerly president of Czecho-Slovakia, who spoke in a notably calm and scholarly manner on "Politics as Science and Art." Thirty-five papers were presented in four half-day sessions; two of these papers were in mathematics, two in astronomy, six in physics, two in geology, six in botany and genetics, four in zoology and physiology, three in anthropology, three in modern history, three in ancient history and archeology, two in philology and literature and one in music. Several of these overlapped two or more fields and are therefore hard to classify.

The fact that the membership of the society includes all these fields of learning, as well as several others, tends to make the presentation of papers less technical and more generally intelligible than is the case in the meetings of more highly specialized societies. This is one of the peculiar charms of these general meetings

which is frequently commented on. At an open forum discussion of the activities of the society which was held on Saturday afternoon, many members said they enjoyed most the papers in fields other than their own, while those who present papers find it profitable and stimulating to attempt to make plain to scholars in other fields the results of their special studies. Some technical societies are at present lamenting the fact that their meetings have become so highly specialized that their programs are uninteresting or unintelligible to many of their own members and they are calling for papers of more general interest. Important discoveries can usually be presented in a manner that is intelligible to scholars in other fields, and if this can not be done they are not suitable for public presentation. Lord Kelvin is reported to have said on one occasion: "That physicist, who, having completed a research no matter how attenuated, on reaching the street can not explain his finding and its usefulness to the first man he meets, should return to his laboratory; his research is not complete."

It is probably true that general societies with non-technical programs do not notably increase knowledge in special subjects, but this is not their function. They do render an important service in stimulating wider interests and in promoting helpful associations among scholars in different fields. A society is first of all a social organization and not a library or laboratory. Information may be obtained in printed form, but nothing can be substituted for the social contacts which are promoted by such meetings.

The hospitality of Philadelphia to learned societies is proverbial, and this makes meetings in the Quaker City most enjoyable. Several years ago, when an international scientific congress was held in this country and was being entertained in various cities the general secretary of the congress telegraphed to the Washington committee asking what entertainment would be provided there. They replied that Washington would do whatever Philadelphia did. The general secretary telegraphed, "Philadelphia meets all hotel and other expenses." At once came back the answer, "Not on your life will we follow Philadelphia." The hospitality of the American Philosophical Society is probably unique among learned societies in this country; its luncheons, receptions and annual dinners are justly famous. But these are not merely gastronomic events but, much more, delightful occasions for social intercourse and scientific conferences. In addition to these general entertainments, the annual dinner given to the council of the society by one of its Philadelphia members is an event which no councillor would ever willingly miss. During the meetings all out-of-town members of the society and their wives as well as other persons who are invited to read papers are the guests of the society at a leading hotel. Undoubtedly this hospitality gives an air of friendliness to the meetings which is most delightful.

The annual business session was held on Friday morning, April 21. The president, Roland S. Morris, in his annual report stated that the invested funds of the society now amount to more than $7,000,000, with an annual income of approximately $200,000 available for general purposes. The budget allots about one half of this sum for grants-in-aid of research, $38,000 for the library, $25,000 for the publications of the society, $6,000 for the expenses of the meetings, about $10,000 for the executive office, $6,000 for the treasurer's office, $4,000 for the maintenance of the building, $6,000 for repairs and about $10,000 for miscellaneous expenses.

The committee on finance, consisting of eight of the leading financiers of Philadelphia who are devoted members of the society, meets regularly once a month and gives constant attention to the finances of the society. The committee on research, publications and library meet five times a year and devote much thought and care to these activities of the society. All committee members serve without personal compensation beyond actual expenses in attending meetings.

On Saturday afternoon, April 22, an open forum of the members for the discussion of the four principal activities of the society was held, and valuable suggestions were made for the improvement of the meetings, the library, the support of research and of publications.

The closing event of the meeting was the annual dinner, at which about 200 persons were present. The John F. Lewis Prize of $300 and diploma for an important contribution made at a stated meeting of the society, was awarded to Professor Henry Norris Russell for his lecture on February 17, 1939, on "Stellar Energy." The citation was made by Professor Harlow Shapley in an unusually happy and instructive speech and was responded to by Professor Russell. Other after-dinner speakers were Victor G. Heiser on his experiences on International Health Board, Jesse S. Reeves on "Neutrality," and Vannevar Bush on "Research and National Defense."

EDWIN G. CONKLIN

THE NATIONAL ACADEMY OF SCIENCES

ABSTRACTS OF PAPERS READ AT THE ANNUAL MEETING

(*Continued*)

Auto-equivalent functions: GEORGE D. BIRKHOFF. An analytic function $f(z)$ of a single complex variable z is called auto-equivalent if there exists a one-to-one analytic deformation $\bar{z}=\varphi\ (z)$ of the neighborhood of $z=\infty$ which modifies $f(z)$ only by a factor $a(z)$ analytic or with a pole at $z=\infty$: $f(\varphi(z))=a(z)f(z)$. The class of auto-equivalent functions, together with its natural extension to matrices, includes an extraordinary variety of functions having fundamental importance in analysis.

Professor Birkhoff outlines his general theory of these functions, which will appear shortly in the *Annales de l'Institut Henri Poincaré.*

Minimal surfaces of general critical type: MARSTON MORSE and C. B. TOMPKINS. Many fundamental theorems in analysis depend upon the existence of a minimum of a function. The calculus of variations extends this theory to functionals. To obtain the point of minimum it is sufficient that the function be bounded below, be lower semi-continuous and the space in which the function is defined be compact. If one seeks all the critical points or configurations in a given problem, for example, the minimal surfaces bounded by a simple closed curve with continuously turning tangent, there are many critical configurations which fail to disclose themselves upon use of the minimum methods. The authors' recent fascicle (Paris) "Functional Topology and Abstract Variational Theory," lays down general principles which can serve to replace the classical minimum principles in general problems. The present paper shows that these general principles can be applied to the theory of minimal surfaces, with proofs of the existence of minimal surfaces without minimum area resulting. This is the first example of an application of the authors' general theory of critical points to multiple integrals and seems to open up a vast new field.

Infra-red absorption of hydrogen fluoride: W. H. RODEBUSH.

Electrophoretic studies on blood sera: DUNCAN A. MACINNES and LEWIS G. LONGSWORTH. The "electrophoretic diagrams" of blood sera have been obtained by a modification of the Tiselius method, in which the gradients of refractive index in the electrophoretic boundaries are automatically recorded. These electrophoretic diagrams indicate the number, the mobilities, the amounts and the relative homogeneities of the proteins present. The diagrams of the sera of normal animals have been found to be characteristic and entirely reproducible. The diagrams for pathological sera show, however, abnormalities, the interpretation of which is only begun. Particularly interesting diagrams are obtained from the proteins of nephrotic serum and urine. Although the distribution of proteins in the nephrotic serum is decidedly abnormal the electrophoretic diagram of nephrotic urine is, very closely, that of normal *serum.*

Responses to different levels of nutritional intake of riboflavin (formerly called vitamin G): H. C. SHERMAN and L. N. ELLIS. It is found in the case of riboflavin (as has also been found with calcium and with vitamin A) that there is a wide zone between the level of merely *adequate* (minimal-adequate) intake and the *optimal* level—that which gives best results in nutritional well-being and resultant health and vitality in long-continued experiments. In the first generation the plateau of externally demonstrable nutritional well-being is attained with intakes about three times higher than the minimal-adequate which supports normal growth and health with successful reproduction and rearing of vigorous offspring. In these offspring there are detectable successive gains in nutritional welfare with successively increased riboflavin value of the family dietary up to at least seven to ten times the minimum adequate riboflavin content of the food mixture. These further gains are, as yet, shown chiefly through increased capacity for growth both on their respective family dietaries and on a riboflavin-deficient diet. The findings are discussed in terms of body storage of riboflavin and of the influence of the level of intake of this substance upon the body's internal environment or general tissue condition.

Experimental results supporting the "fluid flow" theory of the biological action of ionizing radiations: G. FAILLA and K. SUGIURA (introduced by Harold C. Urey). In 1937 one of us[1] proposed a theory of the biological action of ionizing radiations, relating particularly to effects produced in living tissues when only a part of the animal's body is irradiated. According to this theory it should be possible to increase the radiosensitivity of a tissue by increasing its circulation and particularly by injecting (sterile) distilled water into it at different intervals subsequent to irradiation. An experiment to test this point has been carried out during the last six months, using animal tumors as the test tissue. The results are shown in Table 1. These results were obtained by injecting into the tumor 0.5 cc of sterile distilled water a few times a day during the first three or four days following local irradiation of the tumor with x-rays. Similar injections of distilled water into non-irradiated tumors do not cause regressions. Irrespective of any theoretical considerations it is evident that the radiosensitivity of Sarcoma 180 may be increased markedly by injections of distilled water following local treatment with x-rays.

TABLE 1

EFFECT OF X-RAYS AND DISTILLED WATER ON THE GROWTH OF MOUSE SARCOMA 180 IN VIVO

X-ray dose in Roentgens	Per cent. tumor regressions	
	X-rays alone	X-rays + H_2O
500	2	30
750	13	60
1000	50	100
1800	100	100

Degrees of sterility in the female rat held on E-free rations: HERBERT M. EVANS and GLADYS A. EMERSON. It is well known that 500 mg of wheat germ oil or 3 mg of α-tocopherol will enable young mature rat females which have been reared and held on an E-free diet to give birth to normal-sized litters of living young. This curative dose of vitamin E is inadequate shortly after the eighth month of life, but a double or treble dose will act curatively. At the close of the first year of life the birth of living young can still be provoked by the administration of eight to ten times the original minimal effective dose. Older females conceive and implant, but the young can not be rescued by any practicable dose level of vitamin

[1] G. Failla, "Some Fundamental Aspects of the Cancer Problem." Supplement to SCIENCE, Vol. 85, 1937.

E. The cause of what appears to be increasing need for E on the part of the embryos is entirely obscure.

The relief of symptoms in major trigeminal neuralgia (tic douloureux) following the administration of massive doses of vitamin B_1 supplemented in some instances by concentrated liver extract: H. BORSOOK, M. Y. KREMERS and C. G. WIGGINS (introduced by T. H. Morgan and Max Mason). Major trigeminal neuralgia (tic douloureux), a disease of man, offers the following advantages for the study of the physiology of pain and of the chemical physiology of the nervous system. The disease in most cases (96 per cent.) is unilateral, and is restricted to the sensory distribution of the trigeminal nerve. The main symptom is intense facial pain. The effect of parenteral administration of large doses of vitamin B_1 in relieving the pain in this disease has been studied. The vitamin B_1 was given by intravenous injection in doses which varied from 10 mg to 100 mg. This was given every day six days a week. A well-balanced diet was supplemented by a daily intake by mouth of one ounce of an aqueous concentrate of the vitamin B complex containing 1,500 I. U. of vitamin B_1; and of a fish liver oil containing 9,000 vitamin A units (U. S. P. X1) and 1,700 vitamin D units (U. S. P. X1). No analgesics were used. Measurements have been made of the chronaxie and the sensory thresholds of the pain spots in the affected parts of the face and compared with the corresponding points on the opposite side of the face. No difference was observed between the two sides. Eleven cases have been under observation for eleven months; forty-five cases for six months. Of the cases observed for eleven months seven became practically symptom free in three months after treatment was begun and have remained so since without further injection of vitamin B_1. Two improved to a lesser degree. One showed no improvement. Essentially the same results were observed in the other forty-five cases under observation now for six months. In ten cases in which there was no improvement or incomplete recovery following the administration of vitamin B_1 in large doses for three to four months, there has been marked improvement when, in addition to the vitamin B_1, large doses of concentrated liver extracts were injected intra-muscularly every other day. A crude preparation containing one anti-pernicious anemia unit per cc but rich in other constituents of the liver was less effective than a more concentrated preparation which contained fifteen units per cc of the anti-pernicious anemia principle but less of other materials extractable from liver. No cases have yet been treated with liver extract alone. There are among the cases showing marked improvement a number over seventy years old who have had the disease in some instances for more than twenty years.

A law of denervation: WALTER B. CANNON. When nerves which deliver impulses to smooth muscle, skeletal muscle and glands are severed and allowed to degenerate the denervated structures become specially sensitized to excitant or depressant drugs. Nerve cells which receive impulses from other nerve cells may be regarded as being innervated by them. Section of fibers which convey impulses to the nerve cells of a ganglion, for example, renders these cells more sensitive to chemical stimulation. Partial denervation has a similar effect. Likewise, when nerve cells in the spinal cord are partially deprived of the connecting fibers which normally influence them, the "denervated" cells become more readily excitable by chemical agents or by a chemical change in the blood.

The chemical composition of the gaseous nebulae: I. S. BOWEN and A. B. WYSE. The lines hitherto observed in the spectra of the "gaseous" nebulae are for the most part attributable to gaseous elements, such as hydrogen, helium, nitrogen, oxygen, etc. Many of the lines are known as "forbidden lines," since they are not ordinarily observed in the laboratory; in the conditions of extremely low density obtaining in the gaseous nebulae, however, the "forbidden lines" are frequently stronger than the so-called "permitted" or ordinary laboratory lines. We have recently made long-exposure photographs of the spectra of three of the brightest planetary nebulae. In one or more of these objects, more than fifty new lines have been observed, of which nearly one half have been identified. In addition to the gases and a few other elements already known to be present, we find evidence for the existence in the nebulae of silicon and of the metallic elements, magnesium, potassium, calcium and iron. The relative abundance of the various elements in a planetary nebula can be roughly calculated from the intensities of the spectral lines, if the physical conditions of the nebula are taken into account. Such a calculation has been made for one of the nebulae observed, NGC 7027, which happens to be especially suitable for the purpose. (As far as present observations go, there is no reason to doubt that NGC 7027 in its chemical composition is typical of the "gaseous" nebulae in general.) Russell has already determined, in a somewhat analogous manner, the relative abundance of the chemical elements in the sun's atmosphere. In spite of the extreme difference in appearance between the spectrum of NGC 7027 and that of the sun's atmosphere, we find no evidence for any difference in chemical composition between the two objects. When an element is observed in the one object and not in the other, the apparent difference is attributable to differences in physical conditions, such as temperature and density, rather than to differences in chemical composition.

Determination of a stellar darkening coefficient from observations of an eclipsing variable: GERALD E. KRON (introduced by W. H. Wright). It is known, from observation of the sun and the implication of simple theory, that stellar disks are dimmer near their edges than at their centers. The amount of this "darkening at the limb" is an important physical constant; observation of its dependence upon temperature and color would aid theory, and make possible more accurate determination of fundamental physical constants of stars. The eclipsing variables, double stars partially or wholly covering each other during orbital revolution, offer the only known means of observing limb darkening. The way in which the light varies as an eclipse progresses will depend upon the degree of uniformity of illumination of the stellar disks. The shape of the "light curve" is affected also

by other physical constants of the system. These additional constants as well must be determined from the light curve. Altogether the problem is so complex as to make strong demands upon the data of observation. and the precision of photometric measurement has heretofore been insufficient to permit disentangling the effects of darkening from other somewhat similar ones due to other causes. A photoelectric photometer was recently constructed for use with the 36-inch refractor of the Lick Observatory. It employs a Kunz potassium hydride photocell sensitive to deep blue light, operating in the circuit of a direct current amplifier. Good observing conditions, the comparatively large size of the telescope and the use of a special optical device that permits the almost instantaneous comparison of two stars have made it possible to obtain unusually accurate photometric observations. The eclipsing variable YZ (21) Cassiopeiae was observed with this instrument. A complete light curve with two minima defined by 54 normal points having probable errors of ± 0.0011 magnitude was obtained. Approximate values were assumed for six physical constants of the stellar system, namely, the darkening coefficients and radii of each star and the orbital inclination and eccentricity. Corrections to these elements have been derived by a method of "least squares" adjustment newly developed by A. B. Wyse. The derived value of the darkening coefficient is $0.502 \pm .037$. The relatively small ratio of the probable error to the total possible range of the quantity itself (4 per cent.) is an indication of the close accordance of observation and theory, and is regarded as justifying the analytical procedure employed.

Solar variation and weather: C. G. ABBOT. Author presents a diagram showing the average march of departures from normal temperature at Washington for 16 days following 320 occasions of rise or fall of the sun's radiation as measured at Montezuma, Chile. Data were separated into 12 groups, one for each month of the year, for the average march of departures differed from month to month. Well-marked opposition of the curves is shown following, respectively, rise and fall of the sun's radiation. Large solar changes are followed by large temperature departures. Results of the first 6 years agree closely with results of the last 6 years covered. To clinch the demonstration, author computes the march of temperature departures similarly for 16 days preceding the dates of solar change. He correlates the results preceding and following those dates. Prior to solar changes the correlation coefficient between rising and falling cases is $+11 \pm 6$ per cent., which is meaningless. Following solar change the correlation is -54 ± 5 per cent., eleven times its probable error and therefore significant. The separation of temperature departures following rise and fall of solar radiation frequently exceeds 10° and sometimes even 20° F., though the average solar change is but 0.7 per cent. Solar variation, therefore, appears to be a major influence in weather, and if solar constant values accurate to $\frac{1}{2}$ per cent. could be obtained daily they would seem to afford means of predicting details of weather for two weeks in advance.

Geologic growth of Asia: BAILEY WILLIS. Among the generally accepted traditions of geology is the assumption that continents are ancient features of the earth's crust, with essentially their actual form, and that they originated in some primeval stage of cooling or crustal formation. It has long been known that they consist chiefly of granite, which has been uptruded from within the globe, and it is now established that the molten granitic bodies spread out in the form of thin discs in the outer crust. While perhaps several hundred kilometers in diameter, any such disc is usually not over 30 kilometers thick, and the underlying rock is commonly basalt. It is recognized that each one of the great continents is made up of a number of such discs of granite, between which the granitic layer may be relatively thin or be represented by smaller intrusions, or be lacking altogether. Thus the concept that a continent is a vast expanse of primeval granite is replaced by the fact that each continent is a mosaic of comparatively small nuclei, which may be more or less closely contiguous or widely separated. Furthermore, it is established by the relations of the intruded granite to fossiliferous strata or by radio-active analyses of the granites themselves that the intrusions differ greatly in age. Some are as much as one or two billion years old; others reached the outer crust as recently as sixty to thirty million years ago. The younger eruptions have tended to rise around the older bodies or between them and they thus fill in the interspaces. The process constitutes continental growth. It has been in progress since the earliest ages of geologic history and presumably is still active. In this paper the known granitic nuclei of Asia are enumerated, according to the data contributed by British, Russian, Chinese, Japanese and American geologists, and it is shown that continental Asia has grown from a few widely separated nuclei of Archean age to the actual expanse by successive uptrusions of granite, very important additions having been made during the Mesozoic era and some even as lately as in Tertiary time. The conclusions have critical bearing upon theories of continental permanence, continental drift and paleogeography.

A hypothesis of submarine canyon origin: DOUGLAS JOHNSON. The origin of submarine canyons of great depth cut far back into the margins of the continental shelves has been debated for more than fifty years. No wholly satisfactory solution of the problem has as yet been found. The following working hypothesis is offered for consideration: Water expelled from consolidating sediments and water under artesian pressure moving through the sediments may find exit in the form of submarine springs on the deeply submerged seaward face of the continental shelf. Spring sapping on land is known to have produced canyons in a relatively brief interval of time. Spring sapping along the shelf margin continuing throughout long periods of geologic time could conceivably produce the results observed. Past geological conditions are believed to have favored this method of origin. Acceptance of the hypothesis would dispose of most of the difficulties confronting other explanations of submarine

canyon development. The explanation at present most popular, that the canyons are normal river valleys deeply submerged, calls for very great vertical oscillations of land level or sea level. Evidence corroborative of such great changes is lacking. Erosion by submarine currents is widely questioned on the ground that the potency of such currents seems small in comparison with the results achieved. Various other interpretations meet difficulties equally formidable. It is believed that the hypothesis of spring sapping under conditions similar to, but not identical with, those now existing on land has advantages which make it worthy of serious consideration.

Biographical memoir of Wallace Hume Carothers: ROGER ADAMS. (Read by title).

Biographical memoir of Edwin Herbert Hall: P. W. BRIDGMAN. (Read by title).

SPECIAL ARTICLES

AN INTERMEDIATE HOST FOR THE SWINE INFLUENZA VIRUS

SWINE influenza is a disease in which two infectious agents, one a virus and the other a bacterium, are etiologically essential. The disease, either as it occurs naturally in the field or as it is transmitted experimentally in the laboratory, is highly contagious, and no intermediate host is required to explain its epidemiology, once an epizootic has started. However, no satisfactory explanation of how or where the disease persists during the 8 or 9 months elapsing between the yearly epizootics has yet been advanced. During such interepizootic periods the swine population in the middle western hog-raising states is, so far as can be told, free of swine influenza. The bacterial component of the etiological complex, *H. influenzae suis,* can persist apparently indefinitely in the upper respiratory tracts of some recovered swine, but similar persistence of the virus can not be demonstrated. The origin or source of swine influenza virus responsible for the fresh epizootics each autumn thus has remained obscure. It is with the epidemiology of these "first cases" of swine influenza that the experiments to be briefly outlined in the present paper are concerned.

Because the swine lungworm, a nematode parasitic in the bronchioles of the bases of the lungs of swine, enters prominently into the experiments to be described, a short account of its life cycle, as determined by the Hobmaiers[1] and by Schwartz and Alicata,[2] will be given. The cycle in brief is as follows. The embryonated lungworm ovum passed in the swine feces is swallowed by an earthworm, in which it hatches as a first-stage larva. After undergoing development within the earthworm the larva eventually reaches its third stage in which it is capable of infesting swine. It remains in this stage until its earthworm intermediate host is ingested by a swine, when it is liberated, penetrates the swine intestinal mucosa and migrates to the respiratory tract by way of the lymphatics and blood stream. The whole of this cycle can occupy a span of several years for its completion or, under the most favorable conditions, can be completed in slightly less than one month. Lungworms constitute a very common parasite in swine reared under the usual farm conditions.

In the present experiments feces and bronchial exudate, containing embryonated lungworm ova, and adult lungworms were obtained from swine that had been ill of swine influenza for from three to five days. This material, after mincing the adult lungworms with scissors to free their ova, was mixed with loamy topsoil and fed to earthworms. Beginning one month later, earthworms were removed from time to time, from the barrels of earth in which they were kept, for use in experiments. They were fed to swine intact but usually mixed with a small amount of dry grain feed. Two swine fed in this way in the first experiment remained apparently normal, and it seemed that the experiment must be interpreted as negative. These two particular swine had, prior to their earthworm feeding, been used in another experiment during the course of which they had received three intramuscular injections of a suspension of live *H. influenzae suis* at eight-day intervals. They had developed no illness. After the apparently negative result of the earthworm feeding there was occasion to inject them again intramuscularly with a suspension of live *H. influenzae suis.* On the third day following this injection they developed clinically typical swine influenza. With this fortuitous suggestion that a provocative stimulus was required to elicit infection, other similar experiments were conducted. Swine were fed the lungworm-infested earthworms and developed neither illness nor virus-neutralizing antibodies. After a period of observation of from 11 to 30 days they were injected intramuscularly with a suspension of living *H. influenzae suis.* No illness resulted from the first injection. However, when the injection was repeated eight days later, characteristic swine influenza resulted after three days.

In other experiments the procedure was varied to coincide with that of the initial experiment, and in these the swine received two preliminary intramuscular injections of suspensions of live *H. influenzae suis* at

[1] A. Hobmaier and M. Hobmaier, *Münch. Tier. Woch.,* 80: 365 and 433, 1929.

[2] B. Schwartz and J. E. Alicata, *Jour. Parasit.,* 16: 105, 1929–30; 18: 21, 1931; and *U. S. Dept. Agric. Tech. Bull.* No. 456, 1934.

eight-day intervals before being fed lungworm-infested earthworms. After the earthworm feeding, sufficient time for the lungworms to complete their migration to the swine respiratory tract was allowed to elapse. Then the swine were again injected intramuscularly with a suspension of live *H. influenzae suis*. Swine influenza usually resulted on the third day after this injection, although in two instances its appearance was delayed until the fourth and fifth days.

In all experiments the clinical diagnosis of swine influenza was confirmed either by the direct demonstration of swine influenza virus by mouse inoculation or by the development of specific swine influenza virus-neutralizing antibodies in the sera of swine that were allowed to recover. Numerous control swine have been given series of from three to twelve intramuscular injections of suspensions of living *H. influenzae suis* at eight-day intervals with entirely negative results. In like manner no swine fed the lungworm-infested earthworms has developed swine influenza without a provocative stimulus having been first applied. Earthworms that had been fed lungworm ova as long as three months earlier have been used successfully. The results of experiments over longer periods of time are not yet complete.

Swine influenza virus has not yet been demonstrated directly by mouse inoculation, either in earthworms known to be carrying infective third-stage lungworm larvae or in lungworms obtained from swine thought to be ready for provocation. If this finding is duplicated in a larger series of tests it would appear that the virus in the intermediate host is present either in very minute quantities or in a masked form. However, in a single experiment containing two swine, the animals were given the provoking stimulus and one was killed the day before the expected onset of illness. Swine influenza virus was demonstrated in or about the lungworms obtained from the bronchi at the bases of the lung of this animal but not in the anterior lobes usually involved in swine influenza. The following day the second swine in the experiment came down with typical swine influenza. It was autopsied, showed pulmonary alterations characteristic of early swine influenza, and swine influenza virus was abundantly present not only about the lungworms at the bases but in the pneumonic anterior lobes as well.

The present experiments have been conducted with known species mixtures of both lungworms and earthworms. Dr. Norman R. Stoll has kindly identified the lungworms employed as *Metastrongylus elongatus* and *Choerostrongylus pudendotectus,* while Dr. Libbie Hyman has tentatively identified the earthworms being used as *Helodrilus foetidus, Helodrilus caliginosus* var. *trapezoides, Octolasium lacteum* and *Lumbricus terrestris.* Furthermore, all experimental swine thus far employed have been carrying lungworm infestations of various degrees prior to their use. Experiments with single pure species of either lungworms or earthworms or with lungworm-free swine have not yet been completed.

The findings described are tentatively interpreted in the following way. Lungworm larvae from pigs with swine influenza harbor swine-influenza virus throughout their development both in their intermediate host, the earthworm, and in their definitive host, the swine. The virus apparently lies latent within the lungworm after the parasite has finally migrated to the swine respiratory tract and is only liberated or activated to cause infection when a provocative stimulus is applied. In the experiments just outlined multiple intramuscular injections of *H. influenzae suis* are believed to have supplied the provocative stimulus. *H. influenzae suis* does not, however, appear to be specific or requisite as the provocative agent because, in a preliminary experiment, a single intrapleural injection of calcium chloride solution has served equally well in provoking the swine influenza virus infection.

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A CUTANEOUS TEST FOR TUBERCULOSIS IN PRIMATES

THE use of monkeys for experimental purposes has become so common during the past few years that many institutions now maintain permanent primate colonies. The chief single menace to the health of such colonies is tuberculosis.[1] Its incidence for 1936-1938 in the laboratories of the Yale University School of Medicine has been about 30 per cent., as determined by gross post-mortem examination. The desirability of reducing the spread of this disease by isolation of infected animals is obvious. The present report describes the results obtained by a simple diagnostic cutaneous test for tuberculosis.

MATERIAL AND METHODS

All departments in the Yale School of Medicine which maintain primate colonies cooperated in the study. Tests were made on 382 monkeys (353 *Macaca mulatta* [rhesus]; 17 mangabeys; 8 baboons; 4 Java monkeys); from the Departments of Anatomy, Obstetrics and Gynecology, Medicine, Pediatrics, Physiology and Primate Biology. Autopsies were done on 132 animals and the remainder were living (October 27, 1938) when this material was compiled.

The test[2] consists in the subcutaneous injection of

[1] C. R. Schroeder, *Am. Jour. Pub. Health,* 28: 469–475, 1938.

[2] C. R. Schroeder, *Zoologica,* 21: 397–400, 1938.

old tuberculin (Schroeder uses P.P.D.) into the loose tissue about the eye where the erythema and edema of a positive reaction may readily be seen. At first, inoculations were made below the eye; later in the upper lid, since it was found that positive reactions were more conspicuous in the latter region, especially in the sooty mangabeys and Java monkeys in which the upper lids alone are unpigmented. The old tuberculin was diluted 100-fold in sterile physiological saline and 0.1 cc was used as the inoculum, which thus contained 1.0 mgm of old tuberculin. Positive reactions consisted in local redness and swelling. These varied in degree: in severe reaction the eyelids might become closed and necrosis and ulceration of skin might appear, as the reaction subsided. Usually the reaction was visible in 24 hours, increased for two or three days and then subsided gradually. Occasionally positive reactions were not apparent until the third or fourth day. If no reaction was seen by the fourth day the test was considered negative. In the colony of the Department of Pediatrics direct smear examination of suspected material for tubercle bacilli was also made at autopsy.

In reading the tables (I, II and III) attention should be directed to the fact that statistics from the various colonies differ because of the rate of turnover. Thus, the colonies of the Departments of Anatomy, Obstetrics and Gynecology and the Laboratory of Primate Biology are kept for long-term experiments, and new (potentially infectious) animals are rarely introduced. The animals in the Departments of Medicine and Pediatrics are used rapidly in contrast and those of the Laboratory of Physiology somewhat less rapidly.

TABLE I

PRIMATE TUBERCULIN TESTS (APRIL–OCTOBER, 1938)

Department of	Tested	Positive	Negative	Equivocal
Medicine and Pediatrics	136	44	90	2
Physiology	99	8	91	
Gynecology and Obstetrics	64	3	57	4*
Anatomy	59	15	44	
Primate Biology	24	0	24	
Total	382	70	306	6

* Previous immunization with B. C. G.

TABLE II

PRIMATE AUTOPSIES (APRIL–OCTOBER, 1938)

Department of	Total	Positive	Negative	Equivocal	Insufficient data
Medicine and Pediatrics	86	33	51	2	
Physiology	23	8	12	2	1
Gynecology and Obstetrics	3	3			
Anatomy	20	15	2		
Primate Biology	0				
Total	132	59	65	4	4

TABLE III

CORRELATION OF TUBERCULIN TESTS AND AUTOPSIES

Department of	Test and autopsy positive	Test and autopsy negative	Test negative, autopsy positive	Test positive, autopsy negative
Medicine and Pediatrics	23	48	5	3
Physiology	7	12	1	1
Gynecology and Obstetrics	3	0	0	0
Anatomy	12	2	3	0
Total	45	62	9	4

RESULTS

The results are presented below: Table I shows that 70 monkeys, roughly 20 per cent. of the total, furnished positive tests. Table II shows that among 132 autopsies 59, or 45 per cent., revealed the presence of tuberculosis. Not shown in the table is the fact that this was confirmed by finding acid-fast bacteria on direct smear in 31 of 33 trials. The correlation between tests and autopsies is presented in Table III, which shows that 49 positive tests were confirmed by autopsies 45 times, and 71 negative tests were contradicted at autopsy 9 times. In other words, a positive test correctly indicated gross tuberculosis in 92 per cent. of 49 trials, and a negative test incorrectly indicated the absence of tuberculosis in 13 per cent. of 71 trials.

DISCUSSION

Some of the failures in correlation might have been avoided by repetition of the test or by using larger doses. However, even in man the test fails at times, and this test, which is approximately 90 per cent. accurate, is of great service in detecting tuberculous monkeys.

CONCLUSION

The periorbital subcutaneous inoculation of 1.0 mgm of old tuberculin is of practical value as a test for the presence or absence of tuberculosis in several varieties of monkeys.

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THE QUANTITATIVE DETERMINATION OF SOY-BEAN PROTEIN IN SAUSAGE OR OTHER PROTEIN MIXTURES

GOVERNMENT restrictions forbidding the use of soy-bean flour in sausage or other meat used in interstate commerce is based on the lack of a reliable test for the quantitative determination of soy-bean protein in such meat. The nutritional value of soy-bean is not questioned. At the present time no strictly chemical method of assay has proven reliable.

We have recently obtained accurate quantitative results by the use of an immunological method which is both simple and rapid. The method is based on a quantitative precipitin test, the "optimal proportions" reaction, first described by Dean and Webb[1] and subsequently proven by Taylor, Adair and Adair[2] to be well within the limits of accuracy of the best-known chemical methods.

The test depends on the fact that in any antigen-antibody titration system the velocity of the reaction is related to the proportion of antigen to antibody. Thus, for a given antibody, precipitation is most rapid when the ratio of antigen to antibody is at an optimum which can be readily determined. This optimum ratio is a constant for each antibody solution and is independent of the concentrations of either antigen or antibody in any specific test.

For example, suppose a given antigen reacts most rapidly with a given antibody at a ratio of 1 to 50; that is, one part of antigen forms a precipitate with 50 parts of antibody at a faster rate than with 45 or 55 parts of antibody. In fact, any ratio other than 1 to 50 will be slower than this optimum. Then, since this optimum ratio is a constant, the actual concentration of reagents may vary within fairly wide limits. It may be 3 to 150 or 10 to 500 or 25 to 1,250.

It is a simple matter to standardize any particular antibody against a known antigen in terms of optimal ratio. Using this ratio the concentration of antigen in any unknown mixture can be determined.

In the specific instance of quantitative assay of soy-bean protein in sausage, the test is performed as follows:

Rabbits are immunized against a 5 per cent. NaCl extract of soy-bean flour. For practical purposes, it is unnecessary to use purified glycinin. Several courses of injections over three or four months are usually necessary to produce a serum of satisfactory potency. The serum is collected and standardized against known soy-bean flour extract. Its optimal ratio is determined as accurately as possible. This ratio is then a constant for that particular serum.

Sausage containing soy-bean flour is extracted with 5 per cent. NaCl. This unknown extract is then titrated against the standard serum and its ratio determined. By dividing the test ratio by the standard ratio the percentage of soy-bean protein in sausage is given.

For example, a standardized serum had a ratio of 1 to 30 against pure soy-bean flour extract. An extract of sausage gave a ratio of 1 to 3 with this serum. Therefore the sausage contained 10 per cent. of soy-bean flour. The accuracy of the method is limited only by the care with which the test is performed; that is, the ability of the operator to distinguish the most rapidly precipitating tube in a rack of ten or twelve tubes. The specificity of the method is limited only by the phylogenetic relationship of the protein mixture under test, a well-established immunological fact.

Details of the test will appear in a subsequent publication.

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[1] H. R. Dean and R. A. Webb, *Jour. Path. and Bact.*, 29: 473, 1926.

[2] G. L. Taylor G. S. Adair and M. E. Adair, *Jour. Hyg. Camb.*, 32: 340, 1932.

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